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EFFECTS OF RADIATION PRESSURE ON COSMIC DUST

By FRANCIS P. MORGAN

THE galaxies present several problems for which there has never been a satisfactory explanation. The principal of these are:

1. Elliptical nebulae rotate as a solid body, indicating a uniform distribution of matter, although the luminosity gradient indicates the stellar distribution to be far from uniform. The same is true of spiral nebulae within a limited radius, but beyond this radius a lag in the rotation occurs.

2. Elliptic nebulae and the nuclear regions of spirals show a high colour index, indicating a temperature below that which the spectrum would indicate. This has not been satisfactorily explained by interstellar absorption, since the colour index is uniform.

3. The problem of spiral structure.

In considering the above problems, it seems to me that not enough consideration has been given to the effects of radiation pressure on cosmic dust, which makes up at least half, and probably more, of the mass of a galaxy.

If it may seem that the effects of radiation pressure are negligible at stellar distances, it must be remembered that, neglecting the effects of interstellar absorption, the relative values of radiation and gravity are the same at any distance from a star. It is estimated that for a dust particle having a diameter of 0.00001 inch the effects of the sun's radiation and gravity balance. The Swedish astronomer Schalen, from a study of the relationship between the absorbing effects and the reddening effects of cosmic dust, calculates the size of the dust particles

as being of the order of 0.000003 inch. (From "The Milky Way", by Bok.)

For particles of this size, the effects of radiation pressure and gravity would balance in the neighbourhood of a star having the M/L ratio of three, where M is the mass as compared to the sun, and L the luminosity. According to Eddington's mass-luminosity curve, this would be a star of abs. mag. +7, for which the mass would be about 0.57. Thus all stars brighter than abs. mag. +7 should repel the particles while fainter stars should attract them.

The important thing is, however, the average ratios of all types of stars combined. This is found by dividing the average masses of all stars by the average luminosities. From statistical analysis of the luminosity function of stars between abs. mag. −2 and + 7, as determined by Van Rhijn and Schwassman, and Luyten's luminosity function for stars from abs. mag. +7 to +20, and applying this to Eddington's mass-luminosity curve for stars from abs. mag. −2 to +12, and assuming the curve to follow the same bend down to the fainter stars, I find the average ratio of all stars to be 0.8. In other words, the average star has a luminosity of 1¼ times that of the sun in proportion to its mass.

It can be seen, therefore, that were it not for the effects of absorption, and the added mass of the cosmic dust itself, all of the dust in our galaxy would be repelled into outer space by the pressure of starlight. I admit that there are uncertainties as regards the number of stars fainter than abs. mag. +15, and also of the masses of the fainter stars, but I feel that these are well taken care of by the wide margin provided by the low average ratios found for the stars.

When the effects of absorption are taken into consideration, it can be seen that, instead of scattering out of our galaxy, the dust only avoids the regions of highest star density, particularly those regions where giants are present, and localizes in the regions of lowest density. Thus the patchy distribution of star clouds and dark nebulae along the Milky Way is accounted for.

Let us now apply this principle to the nebulae, starting with elliptic nebulae, which is the simplest form of galaxy.

Here the rotational effect is of little importance and there is a smooth gradient in the stellar distribution. The dust avoids the

region of highest density, namely, the centre, and increases in density with increasing distance from the centre at a rate which compensates for the decreasing star density, hence the uniform rotation period. At the outer boundaries the effects of radiation are overcome partly by the absorption of the relatively dense dust particles, and partly by the weight of the same, which increases the force of gravity, thus preventing scattering into outer space.

Since the maximum absorption and reddening effects occur in the outer regions, the uniformity of the colour index is also explained. The high ratios of the system as a whole, as determined by its rotational properties, (56 to 1 for NGC 3115) is also explained by the absorption of this outer aura of dust particles.

The problem of spiral nebulae is somewhat more complicated. Here the high rotational velocity causes both the stars and the dust particles to scatter out into a vast equatorial plane. The increased diameter of the major axis, together with the greater separation between the stars, so increases the effects of interstellar absorption, that the particles are only exposed to the radiation of stars within a limited radius, although under the gravitational control of the entire system.

Thus, instead of scattering to the outer limits, we find dust distributed all the way through the system. But the local effect of the stars' radiation is even greater than in the elliptic nebulae, owing to the number of giants present. The result is a tendency for the stars and dust to separate from each other in much the same way as two liquids of unequal density, such as water and oil, tend to separate, although for a very different reason.

When the rotational effect is added, it is easy to see how these two ingredients which make up a galaxy separate into four spiral arms or zones, two of which are composed of stars and can be observed, and two invisible arms of dust clouds, emerging from the nucleus at a 90° angle to the star zones. Most of the dust is restricted to its own spiral arms by the repulsion of the stars distributed along its inner and outer borders. Within the dust zone the dust is of sufficient density to protect itself against the stars' radiation.

The stars also are mostly restricted to their own spiral arms but for a different reason. Not being themselves subject to radiation

pressure, they choose the region of greatest gravitational stability, which is 90° from the regions of highest density, namely, the dust zones. This does not apply to the high velocity stars, such as the long period variables, which move in elliptical orbits inclined at all angles to the equator.

The uniform rotation period is explained by an increase in the density of the dust zones from the centre outward, which compensates for a corresponding decrease in the star density.

The coiling of the arms is due either to a lag which did exist in the rotation during the early stages of development of the system, before the distribution of matter became equalized, or else to a very small lag which exists to the present time, but too small to be detected by the Doppler effect.

Beyond a certain radius the density of the dust zone must, of course, decrease. Beyond this point an appreciable lag in the rotation occurs and the stars follow approximately Kepler's third law of motion. In M 33 this occurs at a radius of 1000 parsecs, and in our own galaxy at some undetermined point between the sun and the galactic centre, but not less than 3000 parsecs from the sun.

DEPUIS 400 ANS

Par A.-V. MADGE

VERS l'année 1505, un astronome polonais, nommé Nicolas Copernic, soupçonna la fausseté du système géocentrique de Ptolémée. Dans ce système qui fit autorité pendant tout le moyen âge, la terre était fixe au centre du monde. Enfin, Copernic démontra le mouvement double des planètes sur elles-mêmes et autour du soleil et le 24 mai 1543, le premier exemplaire de son célèbre traité *De revolutionibus orbium coelestium*, qui fut publié quelques mois avant sa mort, fut placé dans sa main mourante. En 1609, le mathématicien, physicien et astronome italien Galileo Galilei construisit la première lunette astronomique, au moyen de laquelle il découvrit les montagnes et les vibrations de la lune. La plus grande lunette qu'il ait construite n'avait pas plus qu'un pouce de diamètre à l'objectif, mais elle pouvait grossir approximativement 30 fois. Cette lunette ouvrit la porte à l'infini des espaces! Le 7 janvier 1610, à l'heure du matin, Galilée découvrit 3 satellites de la planète Jupiter et le 14 janvier de l'année même il découvrit une autre lune—sa lunette était trop petite pour trouver les 7 autres satellites de cette planète géante. Les noms des satellites découverts par Galilée sont Io, Europa, Ganymède et Callisto—on donne aux autres les numéros romans V, VI, VII... XI. En 1609, un astronome allemand, Jean Képler, publia les lois suivantes:

1. Les orbites planétaires sont des ellipses dont le soleil occupe un des foyers.

2. Les aires décrites par les rayons vecteurs sont proportionnelles aux temps.

En 1619, il publia la troisième de ses lois:

3. Les carrés des temps des révolutions planétaires sont proportionnelles aux cubes des grands axes des orbites.

Nous avons ici *les lois de Képler* d'où l'illustre astronome et mathématicien anglais Isaac Newton sut dégager en 1665 sa loi de la gravitation universelle. C'est Newton qui découvrit en 1666 au moyen d'un prisme la décomposition de la lumière. Savez-vous que si, dans une chambre obscure, la lumière solaire tombe sur la face d'un prisme de verre, elle subit une action décomposante et en sort

en rayons qui vont se former en une image oblongue présentant les sept couleurs de l'arc en ciel? La lumière blanche décomposée en sept couleurs: le violet, l'indigo, le bleu, le vert, le jaune, l'orange et le rouge, s'appelle *le spectre*. De nos jours, les observations précises des spectres se font avec un instrument scientifique que l'on appelle *un spectroscope*. L'analyse spectrale a été si perfectionnée qu'elle a permis d'étudier la composition chimique des étoiles fixes, des météores, des comètes et de la lumière des nébuleuses tellement éloignées de nous dans l'espace, et ainsi de constater que des matériaux qui entrent dans la composition de notre soleil et de tous les autres astres sont précisément les éléments chimiques que l'on trouve sur la terre—mais pas nécessairement de la même forme!

En 1676, l'astronome danois Rœmer détermina la vitesse de la lumière. Il constata que les éclipses des satellites de la planète Jupiter n'avaient pas lieu exactement aux temps prévus; c'est-à-dire, en comparant les époques des occultations des satellites de Jupiter, il trouva une différence d'un peu plus de 16 minutes et il conclut que la lumière n'avait pas une vitesse infinie et que la différence fut le temps que met la lumière pour traverser la distance du diamètre de l'orbite de la terre. (Dans *The Observer's Handbook* on trouve—Vitesse de la lumière: 299,774 km./sec. ou 186,271 miles/sec.).

En 1796, l'astronome et mathématicien français Pierre-Simon de Laplace présenta dans son ouvrage *Exposition du Système du Monde*, le système cosmogonique qui porte son nom. Il s'occupa surtout des questions de mécanique céleste. Il fit de nombreux travaux relatifs au mouvement de la lune, de Jupiter et de Saturne—citons ses travaux sur les satellites de Jupiter, la vitesse de la rotation de l'anneau de Saturne, les nouvements des comètes, etc.

En 1846, le 24 septembre, l'astronome allemand Galle trouvait la planète Neptune à l'endroit indiqué par l'astronome français Leverrier. Leverrier confirma les idées de Newton sur le système solaire en découvrant par le calcul en 1845 cette planète inconnue. La découverte de la Neptune par le calcul fut le plus grand triomphe de la science astronomique depuis Newton. Un mathématicien anglais, Adams, un peu avant Leverrier, était arrivé au méme résultat que Leverrier mais l'astronome royal anglais, Airy, (le même astronome qui a donné la première théorie complète de l'arc en ciel)

supposa qu'Adams fût incapable et écartât ses supputations. Après la découverte de Neptune il pensa au mémoire d'Adams et le trouva exact. Il faut donc associer Leverrier, Adams et Galle à la découverte de cette planète qui est invisible à l'oeil nu.

Entre les années 1838 et 1846 il y eut des faits d'importance dans la science astronomique. Par exemple, en 1838, l'astronome Bessel trouva la parallaxe de l'objet 61 du Cynge. En 1839, l'artiste français Daguerre perfectionna la photographie. En 1842, la première observation scientifique d'une éclipse solaire. En 1845, la découverte des nébuleuses spirales par le télescope Rosse (un réflecteur construit dans la même année avec son miroir ou spéculum de six pieds de diamètre). En 1845, le premier daguerréotype du soleil par les physiciens français Foucault et Fizeau. (C'est Foucault qui a démontré le mouvement de rotation de la terre au moyen d'un pendule; il fut aussi l'inventeur du gyroscope. Fizeau reprit l'étude de la vitesse de la lumière par des procédés optiques et publia de beaux travaux sur la propagation et la vitesse de la lumière).

En 1856, Foucault découvrit le procédé pour les spéculums télescopiques par lequel on produit l'argenture de la glace en versant sur sa surface un composé de nitrate d'argent, d'ammoniaque et d'acide tartrique. (*For full details concerning the silvering of glass surfaces, see Letter Circulars no. 32 and no. 389 of the United States Bureau of Standards, procurable from the Superintendent of Documents, Government Printing Office, Washington, at about 10 cts. each*). En 1862, Foucault détermina la distance du soleil au moyen de la vitesse de la lumière. En 1868, un physicien nommé Lockyer découvrit l'hélium dans le spectre du soleil—l'hélium fut trouvé dans un laboratoire par Ramsay en 1895. En 1897, l'observatoire Yerkes avec son réflecteur de 40 pouces de diamètre fut érigé. Et, enfin, nous avons le télescope réflecteur de 100 pouces de diamètre de l'observatoire Mount Wilson, le plus puissant du monde, le plus récent et le plus parfait comme construction.

Nous avons très brièvement parcouru le champ astronomique depuis 400 ans. C'est pendant la période qui s'étend de 1543 à 1943 que s'accomplirent les découvertes et les données scientifiques les plus utiles; une ère nouvelle s'ouvrait pour l'astronomie et les autres sciences connexes. Le mouvement scientifique a pris une impulsion

nouvelle. Il a été impossible d'exposer, ici, toutes les belles conquêtes astronomiques—il y a encore des pages à écrire et le livre est encore ouvert. Il nous faut pourtant conclure. La lunette de Galilée ouvrit la porte. Entrez donc! Il y a encore des places de libres parmi les astronomes.

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THE CIVIL WEEK AND MENTAL WEEK

By C. E. White

SO far as man knows, the civil week has always begun with Sunday as the first day of the week and no proposed calendar reform, including The Modified World Calendar, has proposed to change this. However, in the methods I have derived for finding the calendar date for the calendar now in use in all[1] civilized countries and for the Modified World Calendar, I let the mental week begin with Monday for the purpose of simplifying the mental process of finding the calendar date. There are many short cuts in mathematics, and regarding Monday as the first day of the week in this simple mental problem is one of them. Had I regarded Sunday as the first day of the week, the formula for the correction would have been

$$c=2q-r+1,$$

where q and r are respectively the quotient and remainder found by dividing $y-40$ by 4. When Monday is regarded as the first day, the first two terms gives the corection. The greatest advantage comes in getting the value of w in the formulas. Suppose it is Thursday; the number of letters in the abbreviation gives w, but when the mental week begins with Sunday, in general, one would think Sunday, Monday, Tuesday, Wednesday, Thursday and register, 5 mentally. The proposed Modified World Calendar or Modified Gregorian Calendar would have the civil week and the wall calendar beginning with Sunday and would let Seventh Day Adventists worship on Saturday and Methodists on Sunday. After I got through explaining the method of finding the calendar date, my niece, who is a Seventh Day Adventist, said: "But Monday isn't the first day of the week and Sunday isn't the seventh day." After I had explained as above, she said: "But the Devil often gets in his work in unexpected and devious ways". I doubt if he ever used short cuts in mathematics to do so. Her reaction, however, tells us that there is likely to be much opposition from all Protestant churches and Catholic churches if any change in the calendar breaks the continuity of the Sabbaths, Jewish or Christian.

The strongest opposition to the World Calendar or the Eastman Calendar will not come from the small groups that worship on Satur-

day, but from those Protestant denominations that have worshipped for centuries on the Lord's Day. They have better reason for contending that it should remain where it is as the weekly return of the day of Resurrection which carries a deep spiritual significance.[2] It was chosen by God as being the most suitable day for those who love Christ to worship him. He who believes that Christ's life was planned by God from his birth to the Cross must also believe that Sunday, or Sonday, as a day to worship Him was included in that planning. He resurrected Christ on Sunday, he caused him to appear in the clouds on Sunday, and he sent him to be with the apostles on Sunday. He had reason to believe that these things would cause the disciples to regard the day as holy[3] and to worship Christ on that day. Can you think of a wiser plan for changing the day of worship? For many years Jewish Christians worshipped on both days. Paul had quite distinctly laid down from the first days of Gentile Christianity that the Jewish Sabbath was not binding on Christians. In the article, "Sunday", the *Encyclopedia Britannica* quotes much to show that among Christians the observance of the Lord's Day was universal during the century following apostolic times.

The edict of Constantine in 324 A.D. that made Sunday a day of rest and worship in the Roman Empire was a boon to Christianity, but not an act that marks the change from Saturday to Sunday as the day of worship.

There is no reason whatever for thinking that the Sabbath, Christian or Jewish, of the present is not separated from the Sabbath of Christ's time by an integral number of weeks—no calendar reform has changed the week. In the proposed World Calendar there would be only three years out of twenty-eight where this would be true. It would be easier for those who believe in immersion to give up the pool and go to sprinkling than for the strict Sabbatarian to accept the Sunday proposed by the World Calendar as a day of worship. I predict that if there is such a change in the calendar that there will be persons from all denominations who will continue to worship as they do now. Any Protestant family that is forced for conscience's sake to worship on a week day finds they do not fit in with the social, school, and business life of the community; Saturday worship does not interfere with school attendance. It means a loss for the family,

state, and church, if the civil calendar be not in close agreement with the church calendar.

[1]The word all should be underscored because it is not likely that any change in the calendar will even get such world wide adoption.

[2]It would be an advantage to the Jew financially if he could open his shop or other place of business on Saturday and worship some other day.

[3]This feeling was also strengthened by the descending of the Holy Ghost on the apostles and the miracle of the tongues on Sunday. See article, "Sabbath", in *Encyclopedia Britannica.*

CALENDAR DATE BY KEY NUMBER

By C. E. White

IN the following, I show how the method given in my article, "Calendar Reform",[1] for finding the calendar date in the Modified World Calendar can be used with corrections to find the calendar date of the present Gregorian calendar. In that article I showed that the month numbers for the months of each quarter could be remembered by remembering a number of three digits. The number of three digits, I called a key number. The first digit to the left in the key number is the month number of the first month in each quarter, the second digit is the month number for the second month in each quarter, and the third is the month number of the third month in each quarter. The key number for the year 1942 is 361. Thus in determining dates in the Modified World Calendar, we would use 3 in finding dates in January, April, July and October, etc. The following are key numbers for the next five years.

402, 624, 146, 250, 361.

When passing from a common or leap year to a common year add one to each digit, but when passing from a common to a leap year add two to each digit of the preceding key number.

To find dates in the Modified Calendar, we use the formula

$$\text{date} = w - m + 7n,$$

where w is the number of the day in the week, counting Monday 1, and m is the month number. By this formula we find the dates of the

first Saturday in each month to be respectively for the year 1942:

375, 375, 375, 375.

The dates of the first Saturdays given by the wall calendar are:

377, 426, 415, 375,
002, 121, 110, 000.

The numbers in the last series are the corrections that must be applied respectively to numbers in the first series to get the calendar date.

These corrections are easily remembered by the rule:

Add 2 for M and M; add 1 for A and A; add 1 for J and J; also add 1 for Jan. and Feb. of leap years. The only months beginning with M are March and May, the only months beginning with A are April and August, and, excepting January which takes the correction 1 for leap years, the only months beginning with J are June and July. To remove the ambiguity it might be best to state the rule:

Add 2 for M and M and add 1 for A and A, and consecutive J and J, showing that the two months beginning with J come after April.

This will be found to be an easy method of finding the calendar date. *Examples*: (1) It is Friday in May 1942. May is the second month of the second quarter, so $5-6+2=1$, which tells us that May 1 fell on Friday. Hence May 8, May 15, May 22 and May 29 fell on Friday. (2) It is Thursday, October 1942; what is the date? In this case $4-3+7n=1, 8, 15, 22, 29$.

Another method is to let the Wednesday dates in the Modified World Calendar be remembered as a key number and correct by the rule above and add 1, 2, and 3 respectively, for Thursday, Friday and Saturday; and substract 1, 2, and 3 respectively for Tuesday, Monday and Sunday.

The Wednesday dates for this year are date$=3-m$, where m takes values 3, 6, and 1. Hence the Wednesday number is 742.

Since the key number for a common year can be found from the preceding year key number by adding 1 to each of its digits, the Wednesday number can be found by subtracting 1 from each of the digits of the Wednesday number of the preceding year. Since the key number for a leap year can be found by adding 2 to each digit of the key number of the preceding year, the Wednesday number for a leap year can be found by subtracting 2 from the digits of the

Wednesday number of the preceding year. The Wednesday numbers for this and the next seven years are:

742, 631, 416, 375, 264, 153, 631, 527.

The correction for finding dates of Wednesday are the same as the correction applied when the key number is used. Add 2 for M and M, add 1 for A and A, add 1 for J and J and add 1 for January and February of leap years.

Examples: (1) It is Sunday in July 1942; what is the date? July is the first month of the third quarter, hence date=July (7+1−3)= July 5, July 12, July 19, or July 26. (2) It is Thursday in November; what is the date? Here date=Nov. (4+1)=Nov. 5. For six months out of the year there are no corrections for common years. Thus for this year 1942, Wednesday falls on the 7th of January and October, on the 4th of February and November and on the 2nd of September and December.

The Wednesday number for any year can be determined from the wall calendar for that year. Since the dates for October, November, and December, the first date for Wednesday in October will give the first digit to the left, and the first date that Wednesday falls on in November and December give respectively the other two digits. For common years, the first January date for Wednesday, the February date and the March date minus 2 will give the Wednesday number; for leap years subtract 1 from the January and February dates. Having determined the Wednesday number[2] in this way, fix it in the mind for future use. This method is independent of formula.[3]

[1]This JOURNAL, vol. 35, p. 343, 1941.

[2]The key number for 1940 is 146. As above we find the Wednesday number for 1940 is 264, a number easily remembered. Since the key number for any year can be found by adding $r-2q$ to each digit of 146, the Wednesday number can be found by adding $2q-r$ to the digits of 264. Thus for the year 1953, $q=3$, $r=1$ and $2q-r\pm5$ and the Wednesday number=742.

[3]I find it more convenient to use a Sunday number which in like manner can be derived from the wall calendar. For 1942 it is 416 and for 1943 it is 502. The formula is:

$$\text{date}=w+m+\text{cor.}+7m.$$

DATES BY THE SUNDAY NUMBER

By C. E. White

IN my article, *Calendar Dates By Key Number*, in a note I called attention to a method of finding the calendar date by a Sunday number which is a number of three digits—the units digit being the date of the first Sunday in December of the current year, the tenths digit being the date of the first Sunday in November of the current year, and the hundreds digit being the date of the first Sunday in October.

I think this method is the most convenient of the methods for finding the calendar date and that its practical value is such that it deserves more emphasis than that given in a short note. However, the method is so closely related to finding the calendar date by key number, the complete development of the method would include the mathematics of that article. The close relationship is made evident by the fact that if we subtract the key number for the year from 777, we get the Sunday number. Thus, 777 −361, the key number for 1942, gives 416 the Sunday number for 1942.

The definition given in the first paragraph makes the method an adjunct to the wall calendar for the current year. Since there are 31 days in October and 30 days in November, it is easily seen that the last two digits can be found by adding 4 and 2, respectively, to the hundreds digit. Since in common years the first Sunday in January comes on the same day of the month as the first Sunday in October, we can use the date of the first Sunday of the year for the first digit—except that 1 must be added for leap years. The other digits can be found by adding, respectively, 4 and 2 to the first digit but in case the sum is greater than 6, 7 must be subtracted. Thus for the year 1943, the first digit is 3, the second $3 + 4 - 7 = 0$, and the third $3 + 2 = 5$ and the Sunday number is 305.

To make the method independent of the wall calendar we can by the method used in deriving the correction in the article *Perpetual and Mental Calendar*[1] derive a formula for determining each digit. If y be the year of the century and s_1, s_2 and s_3 be the digits of the Sunday number and q and r the quotient and remainder when $y-40$ is divided by 4; then

$s_1 = 2q - r - 1$, $s_2 = 2q - r + 3 = s_1 + 4$, and
$s_3 = s_1 + 2 = 2q - r + 1$.

Thus, for the year 1958,

$y = 58$, $y - 40 = 18$, $_q = 4$, $r = 2$, $s_1 = 5$, $s_2 = 2$, $s_3 = 0$,

and the Sunday number is 520.

To extend the method into the next century, we observe that we must divide $100 + y - 40$ by 4, where y is a year of the next century; but since $100 - 40 = 56 + 4$ and $2\ (56/4) = 28$, a multiple of 7, we can determine the q and r by dividing $y + 4$ by 4, or by dividing y by 4 and adding 2. Hence for the next century

$$s_1 = 2(y/4)_q - 2(y/4)_r + 1,\ s_2 = s_1 + 4 \text{ and } s_3 = s_1 + 2$$

where the sub. q indicates that the integral part of the quotient is to be used and the sub. r indicates that the remainder is to be used.

Let it be required to find the date of the first Sunday in November 2042. Here

$q = 10$, $r = 2$, $s_1 = 20 - 2 + 1 + 7 = 5$, $s_2 = 5 + 4 - 7 = 2$,
$s_3 = 5 + 2 - 7 = 0$, and $s_1 s_2 s_3 = 520$,

which is the same as for the year 1958, but it should be the same because $2042 - 1958 = 84 = 3 \times 28$ years and dates relative to the days of the week repeat themselves every 28 years. Since November is the second month of the quarter, we use 2 as the date of the first Sunday. Adding 7, 14, and 21, we get the dates of the other Sundays.

For one who makes constant use of the method, the quickest way to get the Sunday number is to subtract 1 from each digit of the preceding Sunday number in passing to a common year but subtract 2 in passing from a common to a leap year.

To make practical use of the method, one must remember the Sunday number and remember that the first digit plus a correction when necessary is the date of the first Sunday of the first month of each quarter; that the second digit plus the correction, if there be any, is the date of the first Sunday of the second month of each quarter, and that the third digit plus the correction is the date of the first Sunday of the third month. One must also remember the rule that determines the correction:—Add 2 for M. and M. and 1 for A. and A. and consecutive J. and J. and also add 1 for January and February of leap years.

To find the date of any day of the week, there is no rule to remember. You must use your eyes and your ears; for Mon. add 1; for Tu. add 2; for Wed. (three letters) add 3; for Thur. (four letters) add 4; for Fri. add 5; for Sat. add 6, of course. So easy, don't you get it? If so, use it.

It is Wednesday in February 1943, what is the date? The Sunday number is 305. Hence $0 + 3 + 7n = 3, 10, 17, 24$. What is the date of the first Saturday in July? Here, $3 + 6 + 1$ (the correction) $- 7 = 3$. For the derivation of this rule see article herewith. In the proposed Modified World Calendar suggested in the article *Calendar Reform* (this JOURNAL, October 1941), the same method could be used except that corrections would not be necessary. For the World Calendar the Sunday number would be 152 for each year.

Addendum

For this century and the next, there will be only seven distinct Sunday Numbers, but each will be repeated four times in each Solar Cycle. They are:

042, 153, 264, 305, 416, 520, 631.

The terms of this series can be determined by $042+111n$, where n takes values from 0 to 6, or for any year $n=s_1=s_2-4=s_3-2$. Hence knowing the day of the week and date it falls on or fell on, we can determine the Sunday Number. For example, Dec. 11, 1942, fell on Friday. Hence $11=5+s_3$ and $s_3=6$ and $n=4$; and $042+111\times4=416$, the Sunday Number. It should be observed that the addition indicated in the formula differs from arithmetic addition in that if the sum of two digits is greater than 6, seven is subtracted; thus, $.042+666=631$.

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[1]This JOURNAL, July-Aug., 1941.

HER MAJESTY'S MAGNETICAL AND METEOROLOGICAL OBSERVATORY, TORONTO

By A. D. THIESSEN

(Continued from page 65)

PART VIII.—LIEUTENANT JOHN HENRY LEFROY, R.A., DIRECTOR, HER MAJESTY'S MAGNETIC OBSERVATORY, 1842-1853. (Letters from Nov. 26, 1844 to April 14, 1846.)

LIEUTENANT LEFROY found on taking over the observatory at Toronto that the work had fallen "terribly in arrears." And being also greatly absorbed in his approaching journey to the north-west, he had no time, even for falling in love, "though the shadow, or more truly the sunshine, of coming events then dawned upon me."[57] For, when the "hospitable doors of Beverley House",[58] opened to him and he went down to dinner with "the lovely eldest daughter of the house, then in her twenty-second year," he "thought her, as indeed she was, the most beautiful girl . . . who had ever met my eyes." He added, however, with characteristic honesty and scientific accuracy: "with perhaps two exceptions."[59]

But when he returned from his north-west survey, on December 5th, 1845, it was not long before he renewed his acquaintance with the family in Beverley House. "The spring of 1846 was made memorable by my happy engagement to the eldest of Chief Justice Robinson's daughters . . ."[60] and on April 16th, "amid public rejoicings not very often elicited by merely domestic happiness,"[61] Emily Robinson and Henry Lefroy were married.

The young couple left for England in the afternoon, going by railway to Buffalo, and sailing from Boston in the S.S. *Caledonia* on May 1st. At Buffalo "some rogue managed to steal one of my many boxes, and it happened to be one which contained the journal or log of my North-West journey, a loss I have never ceased to deplore."[62]

While in England, Lefroy spent much time learning about the use of photography in magnetic registration, and in other ways busied himself for the benefit of the Toronto observatory. "Al-

though unable to avoid a certain amount of business on this my wedding tour, I did as little as I could."[62]

They returned to Toronto in November, arriving in Beverley House on the 21st, where they remained "until the observatory cottage was ready for [their] reception. This was not before February 18th, 1847, and three days later Harry was born. . . . The cottage was of very slight construction, and difficult to warm. I have often seen the water on the wash-handstand in our bedroom frozen solid; that in the water-bottles, having an open neck to expand into, would sometimes overflow in ice round the neck without bursting them."[63]

The letters published in the present Part belong to the period between Lefroy's return from the north (Nov. 26, 1844) and his departure for England on his wedding journey (April 14, 1846).

Magnetical Observatory,
Toronto, Nov. 26, 1844.

Sir,

I have the honor to state that Lieut. Lefroy and Corporal Henry, Royal Artillery, arrived in Toronto on the 18th instant.

Clothing for the year 1844-45 is required for Corporal Henry.

I have, etc.
C. W. Younghusband
Lieut. Royal Artillery

Lieut. and Adjt. Harvey,
Royal Artillery, Kingston.

The work was in arrears and there were not enough men to do all that was required, particularly when valuable time was lost in fetching stores and provisions daily from the garrison two miles distant.

Magnetic Observatory, Toronto,
10th December, 1844.

Sir,

The 31st Paragraph of the Treasury Minute of Dec. 1st, 1843, provides that "In consequence of the distant residence of many of the staff officers in the colonies from the commissariat magazines and the inconvenience to which they would be exposed by the obligation of drawing their rations every three days the staff returns will continue to be monthly, etc. (Form No. 15)." I have the honor to request that you will lay before His Excellency the Commander of the Forces an application that he will be pleased to authorize the Rations to be issued to this establishment under the same form, from and after the 1st January 1845. I beg leave to represent that the preparation of the returns every third day is felt

as a great inconvenience, as the time of the N.C. officers of my establishment is fully occupied by their duties in the magnetic observatory, the necessary scientific returns of which are much in arrear. The distance of the observatory from the commissariat department is about two miles.

The present application is a renewal of one to the same effect in Lieut. Younghusband's Letter of 10th April 1844,[65] and which was passed over in the reply to the same dated 17th April, 1844.

I have, etc.

J. H. Lefroy[65]
Lieut. Royal Artillery
In charge of Magnetic Observatory

The Military Secretary
etc., etc., etc.,
Montreal

This inconvenience had now endured for more than four years! It is mentioned in a letter written by Lefroy on May 28, 1845, when in reference to the attendance of the Senior Officer of the Royal Artillery attached to the Observatory at meetings of the Board of Respective Officers he suggested "that it appears to me that the duties of a member of the Board will require the use of a horse."

The same inconvenience was mentioned again when wood used in the Observatory had to be piled. The regulations for fuel required "that wood issued to the troops, be piled by the troops receiving it, in the Commissariat woodyard, before it is drawn." But Lefroy went on to say,

Observatory, Toronto,
7th January, 1846.

"The quantity allowed to the magnetic observatory and detachment is about sixteen cords monthly. There is only one orderly Gunner belonging to the observatory who could be employed in piling it, and his time is fully occupied immediately about the establishment, from which the woodyard is two miles distant. Under these circumstances I have the honor to request that an exemption from this regulation be granted, as regards the allowance for the magnetic observatory.

I have, etc.

J. H. L.

Lieut. Col. Mackay,
Commanding the Garrison.

A year later Lefroy was able to announce that the accumulation of work in arrear had finally been cleared off.

Magnetic Observatory
Toronto, 21st Nov., 1845.

Sir

In transmitting to you the magnetical returns for the last expired period of two months I feel it an act of justice to the N.C. officers attached to the observa-

tory, as well as pleasure to myself to make a particular report to you of the manner in which they have exerted themselves to clear off the accumulation of work in arrear, to which you may remember to have directed my attention on my return from the north-west in November, 1844.

I do so the rather, because although that accumulation was not caused by any deficiency of exertion on their part, but to circumstances over which we had no control, the complete disposal of it is due particularly to their zealous and persevering endeavours.

I have, etc.

Lieut. Col. Sabine, R.A., J. H. L.
Superintendant of Magnetical
Observatories, etc., etc., etc.

Lefroy himself deserves credit for the manner in which the time of his assistants was employed and saved against interruption by regimental duties, and, as we have seen, he did not spare himself in the work that had to be done.

Toronto, February 15, 1845.

Sir,

I have the honor to forward to you a copy of a letter received from the Acting Adjutant of the Royal Artillery in Canada West, and of my reply. I thought it necessary to make the remark upon the return in question, although of an unimportant nature because it appeared unnecessary, if the Officers of the Royal Artillery at the magnetic observatory are not under the command of the Commanding Officer at Kingston, that he should make any reference to us upon the subject of our being provided with the necessary Regimental books, and as it is understood that Lieut. Col. Maclachlan is about to be relieved, and it appears probable in the event of the Government equipping a North Polar expedition that the magnetic observatory at Toronto will be continued beyond the present year. I thought it desirable to take steps to reassert before the assumption of the command by another officer that independence which has been given to the officers employed upon this service, to secure them from the interruption of mere regimental routine, and from the exercise of authority which might possibly be exerted without intention, to the obstruction of their peculiar duties.

I have communicated a copy of this letter to Lieut. Col. Maclachlan, and have the honor to be, etc.

J. H. L.

Lieut. Col. Sabine, R.A.
Superintendent . . .
Magnetical Observatories

Lefroy was equally jealous of his own time and authority, and on the same date wrote to Lieut. I. Harvey, Acting Adjutant of the Royal Artillery at Kingston, stating that

with reference to that part of your letter requesting me to transmit to the Office of the Commanding Officer, Kingston, a return of the names of the Officers of the Royal Artillery at the Magnetical Observatory, who have not provided themselves with a copy of the new edition of the General Regulations, I beg leave to state that I do not conceive that I am liable to be called upon to make a return of this nature to the Officer Commanding the Royal Artillery at Kingston not being personally in that command. I have therefore forwarded a copy of your letter to Colonel Sabine and await his further instructions.

The expenses of the Toronto Observatory were considerably greater than could be covered by the annual grant provided for its conduct, and, as has been several times mentioned before, renewal of the grant from year to year was dilatory. These things added to the problems of the officer in charge.

Toronto, January 28th, 1845.

Sir,

I have the honor to forward to you a statement of the contingent account of the magnetic observatory, Toronto, up to the present date. By which it appears that owing principally to the extensive additions made to the instrumental resources of the observatory, to enable it to carry out the instructions from time to time received and keep pace with the improvements in observations which have been devised since its first establishment, a debt has been incurred which the sum granted for contingent expenses of instruments supplied for the magnetical survey of North America, and which have been charged to contingent account. It appears by the treasury minute of 16th April, 1841, that a sum of £130 was granted for those expenses, but the ordnance storekeeper having received no orders about that sum it has not been credited by him to the account of the observatory.

The total amount at present outstanding against the observatory as far as known is £323 - 2 - 11 for which the accounts have been presented and remain unpaid for want of funds.

I cannot recommend any application of the Balance of the travelling contingent, amounting to £107 - 0 - 6½, towards the liquidation of the above debt, as the magnetic survey of the Canadian provinces, is far from being completed and can only beg to submit to you the expediency of an application in the proper quarter for a renewed grant.

I have, etc.,
J. H. L.[66]

Col. Sabine,
Royal Artillery,
etc., Woolwich.

The question arose again at the end of 1845.

Magnetic Observatory, Toronto,
December 22nd, 1845.

Sir,

I have the honor to request that you will lay before His Excellency the Com-

mander of the Forces, an application that he will be pleased to give a temporary authority to the Respective Officers at Toronto, and to the Commissariat Department, for the continuance of all allowance of fuel, light, and rations, at present issued to the officers, N.C. officers and men of the Royal Artillery, attached to the magnetical observatory and of fuel and light, issued for the use of the observatory, for which the present authority expires on the 31st of December next until the sanction of H.M. Treasury for the continuance of the establishment be received by the Respective Departments.

In explanation of the present application, I have the honor to annex an extract from a letter from Lieut. Col. Sabine, R.A., Superintendent of the Ordnance Magnetical Observatories, announcing the fact of the intended continuance of the magnetical observatory at Toronto, and to state that I apply to His Excellency in consequence of having ascertained from the Assisting Commanding General at this station that "he does not think he would be justified in continuing the issue of the allowances without a special authority for the purpose being procured from the Commander of the Forces."

I had the honor in February, 1843, when the continuance of the observatory for the term of three years just expiring, was authorized, to make a similar application to the late Commander of the Forces, in consequence of a delay in transmission of the regular notification from England, His Excellency's approval was signified by the Military Secretary in two letters:

5013 17 February, 1843;
5135 27 March, 1843.

I have, etc.
J. H. L.

The Military Secretary,
Montreal

Extract from letter from Lieut. Col. Sabine, R.A., Superintending Ordnance Magnetical Observatories, to Lieut. Lefroy, R.A.

Woolwich, 29th October, 1845.[67]

"I learnt to-day from the Chancellor of the Exchequer (the last authority in such cases) that our observatories are to be continued according to the recommendation of the conference. He promised me that he would write to Sir George Murray to tell him that such was the intention of the Government."

[A true extract]
J. H. L.

During this period the routine of the office appears to have continued smoothly. There were the usual requests for great coats in November and December, and occasional complaints about the quality of the bread and the candles issued to the observatory.

Observatory, 3rd January, 1845.

Sir,

I beg leave to make a report to you of the bad quality of the ration candles

supplied by the commissariat to the Magnetic Detachment, and for the service of the observatory. They appear to be inferior to those heretofore issued, and not fit for the purposes to which they are applied in the magnetic observatory.

I have, etc.

J. H. L.

The Commanding Officer,
etc., Toronto.

Toronto, January 24th, 1846.

Sir,

I beg permission to make a report of the inferior quality of the ration bread recently supplied to the Detachment of the Royal Artillery at the magnetic observatory. It appears to be adulterated, and several of the men have been troubled with bowel complaints, which they attribute to the use of it.

I have, etc.

J. H. L.

Lieut. Col. Mackay,
82nd Regiment,
Commanding the Garrison,
etc., Toronto.

On December 4th, 1844, an officers' mess was established at the observatory. As many of the meteorological instructors attached to the flying schools in the British Commonwealth Air Training Plan (1942) are quartered in officers' barracks, certain arrangements in the service have come full cycle in a century.

Magnetic Observatory, Toronto,
February 26th, 1845.

Sir,

. . . I have the honor to inform you that the officers of the Magnetic Detachment *bona fide* live and mess together, and in common, in the manner customary to officers on Detachment together. They have therefore established a mess, which is now in operation, and has been since 4th December ultimo.

I have, etc.

J. H. L.

Col. Hon. C. Gore, K.H.,
Deputy Quartermaster General,
etc.

Disciplinary problems, arising from the administration of an observatory as an army barracks, have been mentioned above.[68] They continued under Lefroy as they had begun under Younghusband. Menzies, who was last mentioned as having been "married with leave",[69] is mentioned only in the most favourable terms in subsequent notices.

Observatory, Toronto,
30th December, 1844.

Sir,

I beg leave to refer to your favorable consideration the general conduct of Gunner and Driver Menzies, since his reappointment to the magnetic observatory in June, 1843, and to request that you will be pleased in consideration of his excellent conduct, and very intelligent services at this establishment to restore him to his rank of acting N.C. Officer.

I have, etc.
J. H. L.

Lieut. Col. Maclachlan,
Commanding Royal Artillery,
etc., Kingston, Canada West.

Magnetic Observatory, Toronto,
June 2nd, 1845.

Sir,

Twelve months having expired since the appointment of Gunner and Driver Thomas Menzies to the magnetical observatory on June 2nd, 1844, during which time his conduct has been entirely satisfactory, I have the honor, in accordance with your letter of January 4th, 1845, to recommend him as deserving of promotion, and to request that you will be pleased to recommend him to Colonel Campbell for the purpose of being made an Acting Bombardier.

I have, etc.
J. H. L.[70]

Lieut. Col. Maclachlan
Commanding Royal Artillery,
etc. Canada West.

With a few other members of the observatory staff Lefroy was not as successful as he was with Menzies. For on January 12th, 1846, he wrote to Lieut. Col. Dalton, R.A., Commanding Royal Artiller, Canada West:

I regret to be under the necessity of bringing to your notice the repeated misconduct of Bombardier William Grace of Captain Symond's Company, 1st Battalion, attached to the magnetic observatory, which now obliges me to request that he may be relieved from his present duties at the earliest opportunity, and I have the honor to request that an intelligent unmarried N C. officer, or Gunner, may be sent to supply his place as an assistant in the magnetic observatory. The duties require a man of steady and trustworthy habits, of intelligence, and capable of writing and copying with accuracy. There is no accomodation for a married man on the spot, nor could one be retained without difficulty and expense. I beg to state however that I should prefer endeavoring to make some arrangement for the accomodation of a married man, of suitable intelligence and trustworthiness, to the reception of an unmarried man deficient in those essential qualities.

Nothing appears to have been done about Grace at this time. His case came up again a few months later during Lefroy's absence in England. (See letters below, dated July 9, 20, 23, and 27, 1846, in Part IX.)

The most striking incident illustrating disciplinary problems is that of the family of Gunner and Driver George Cooper, batman to Lefroy. It throws an interesting side light on the character of Lefroy, who impressed his friends and all who came into contact with him, with his humanity and profound sense of justice. He mentions the case of Cooper in his memoirs with a sense of regret:

> About March in this year (1846) I got involved in a very painful business. My eyes were opened to the infamous life led by the wife of my soldier servant, to the habitual drunkenness of both of them, and to the disgraceful condition in which they lived in an old blockhouse in Spadina Avenue. I could not plead entire ignorance; instances of misconduct had been brought to my notice, but I had never properly investigated them. The blockhouse, though not far off, was quite out of my line. Ultimately the woman died of drink and destitution. The only child, a girl, whom I placed with respectable people and sent to school, followed her mother's vicious ways. The unhappy father, originally a steady man until his wife's misconduct drove him to drink, died also, I do not remember how, and I had the bitter reflection that timely severity and greater exertion on my part might have possibly saved the whole family. I record this painful experience for the lesson it gives of the consequence of evading responsibility and indulging a good nature, which is nothing but sloth. I ought to have sent him back to his military duty at Kingston long before the thing came to a crisis.[71]

Three letters, dated March 25, 27, and 31, 1846, bearing on this case, are here printed without comment.

Magnetic Observatory,
25th March, 1846.

Sir,

Being about to discharge my servant, Gunner and Driver George Cooper, 3rd Battalion, Royal Artillery, and having no occasion for him, on this Detachment in any other capacity, I have the honor to request your sanction to his being borne on the strength of the Detachment of the Royal Artillery at the Fort, until instructions are received from Kingston for the further disposal of him. I have, etc.

J. H. L.

Lieut. Col. Mackay,
H.M. 82nd Regiment,
Commanding the Garrison.

Toronto Magnetic Observatory,
27th March, 1846.

Sir,

I have the honor to report to you that I have discharged my servant Gunner and Driver George Cooper, 3rd Battalion, for repeated acts of drunkenness, and having no employment for him on this Detachment in any other capacity, I have made application to Lieut. Col. Mackay, 82nd Regiment, Commanding the Garrison, for permission to attach him to the Detachment of the Royal Artillery at the Fort, to which he has been pleased to accede, and the man has this day joined the Detachment.

I beg to state that Gunner Cooper has been in my service since September, 1837, and up to a recent period has conducted himself to my satisfaction. I have found him perfectly honest and trustworthy, and in other respects a valuable servant, but having contracted the vice for which he is now reported, and under circumstances which give me little hopes for his reformation, I find it impossible to retain him any longer. There are no entries against him in the Defaulter Book, but the circumstances of his last offence, should they be required for entry at Kingston, are as under:

March 25th, 1846, Gunner and Driver George Cooper, 3rd Battalion, Servant to Captain Lefroy, absent from his duty on the morning of the 26th, found drunk; reported by Serjeant James Johnston, witness, Gunner McNulty.

Being the 3rd offence since January 1st, 1846, dates of previous offences, January 6th and February 4th. Discharged by Captain Lefroy, and reported to the Commanding Officer at Kingston.

I have the honor to state further, that having made an application for leave of absence from 16th April, proximo, it is not my wish to have another servant detailed to me for the short intervening period, unless that application is refused.

I have, etc. J. H. L.

Lieut. Col. Dalton,
Commanding Royal Artillery,
Canada West.

Observatory, Toronto, 31st March, 1846.

Sir,

With reference to Gunner Cooper, lately my servant, whose misconduct I have recently reported to you (27 March, 1846), I have the honor to state that I visited the quarter occupied by the Royal Artillery at the Fort. I find their room occupied by four married men, all of them having permission to live in Barracks, and everything in it [is] arranged with so much order and cleanliness, and so much to their credit and that of the N.C.O. in charge, that I have felt reluctant to order Gunner Cooper into that room, although he has been ordered to join that mess, and have permitted [him] to occupy the block house near the magnetic observatory and to return the barrack bedding, etc., issued on my requisition. In other respects he does duty with the Detachment under Bomber Powell. Since however this quarter is nearly 2 miles distant from the Fort and it is difficult to exercise proper discipline over him while there or to inflict confinement to barracks should he incur that punishment, I have the honor to request

instructions whether he is to be ordered into barracks, or how to be disposed of. I beg to state his wife is a woman of the worst character, totally unfit to be admitted into barracks. I feel it my duty to take this opportunity of qualifying the character which I gave of Gunner Cooper. It has come to my knowledge since his discharge from my service, that he has contracted debts to a large amount in Toronto, which it will be necessary to put him under stoppages to discharge. It is proper to add that as a servant, I am not acquainted with any acts of dishonesty on his part.

I have, etc.
J. H. L.

Lieut. Col. Dalton,
Commanding Royal Artillery,
Canada West.

During Lefroy's absence in England two more letters were written about this case.

Toronto, Canada,
October 29th, 1846.

Sir,

In compliance with the request of Lieut. Col. Dalton contained in your letter of the 16th ultimo (which was not received until the 21st) that I should procure information respecting the wife of the late Gunner and Driver George Copper.

I herewith enclose a statement of her case drawn up by Dr. Telfer, the Medical Gentleman in charge of the Lunatic Asylum.

I have, etc.
C. W. Younghusband, etc.

Lieut. and Adjutant
Mackay, Royal Artillery,
Kingston.

Memorandum of Amy Cooper's Case

On the 11th of July last, she was sent from the jail by the authorities. She is a soldier's wife stationed at Kingston. The cause of her insanity is *Intemperance*. It appears in the form of mania, and [she] has since her admission made frequent attempts to destroy herself. She is recovered in some measure, but cannot be trusted alone.

(Signed) Waller Telfer, Medical Superintendent,
Toronto Provincial Lunatic Asylum,
28th October, 1846.

Although Lefroy applied for "leave of absence from the magnetic observatory, to return to England, for six months from August 25th next" in a letter dated June 26, 1845, on Nov. 10th, 1845, he had still not received a reply. He then applied for leave from February 1st, 1846. "In addition to particular private affairs" he assigned "the injurious effect of [his] present duties upon [his] eye-

sight, as a reason for desiring a temporary relief from them". In his letter to Sabine dated November 10, 1845, he added that he thought "a visit to England would be an advantage to [him] in relation to the duties on which [he] was employed."

On December 16th, 1845, Lefroy notified Lieutenant Colonel Dalton, Commanding Royal Artillery in Canada West, that he had received leave of absence to commence February 1st, but "the time which has intervened in the transmission of the reply has been the occasion of a change in the circumstances under which the application was made. I am not now desirous of availing myself at once of this leave and propose to take no further steps until the spring, when it is my intention, should my duties permit it, to forward the approval of the Master General for the authority of His Excellency the Commander of the Forces."

On April 14, 1846, Lefroy was ready to leave, and he wrote the following letter. He could not forget his work even on this his wedding journey.

Observatory, Toronto,
April 14, 1846.

Sir,

I beg leave to recall to your recollection that in May, 1845, three boxes were forwarded to Quebec by the Ordnance Storekeeper at Toronto, containing instruments, etc., from the magnetic observatory addressed to Colonel Sabine, Woolwich, and intended to be shipped in a Transport which sailed about that time. Owing however to want of clear instructions on that point, they were not shipped for England, and two of them, I believe, are still in your store, one of them having been returned to Toronto in November, 1846. I beg leave to state that I am about to return to England myself and shall be obliged if you will take the earliest opportunity of forwarding as Government freight, if possible, but if no early opportunity is likely to offer, then as private freight, in order that they may arrive and be attended to during my stay in England. I would further beg the favor that they may be readdressed to Lieutenant Colonel Sabine, Superintendent, Magnetical Observatories, Woolwich.

As I shall have left Toronto before the navigation opens, it will not have the same effect to return them to Toronto.

I have, etc.,
J. H. L.

The Ordnance Storekeeper,
Quebec.

During Captain Lefroy's absence Lieutenant C. W. Younghusband was again placed in charge of the observatory.

HER MAJESTY'S MAGNETICAL AND METEOROLOGICAL OBSERVATORY, TORONTO

PART IX.—LIEUTENANT C. W. YOUNGHUSBAND, R.A., IN CHARGE OF THE TORONTO OBSERVATORY DURING CAPTAIN LEFROY'S ABSENCE IN ENGLAND FROM APRIL 14 TO NOVEMBER 20, 1846

IN his last administration of the Toronto Observatory, Lieut. C. W. Younghusband continued the work, most of it normal routine work, as it had been begun by Lieut. Riddell and continued by himself and Lefroy. As we have seen, he closed the case of the unfortunate Mrs. Cooper. He also dealt with William Grace as required.[72]

Another member of the observatory staff at this time received promotion. Corporal William Henry, Lefroy's batman on the magnetic survey of northern Canada, was "promoted to Serjeant by augmentation".[73]

The status of the observatory, its financial support, and the cost of the magnetic survey were also mentioned in one of Younghusband's letters, which follows, and there were further requests for, and reports on, clothing rations.

Toronto, 28th September, 1846.

Sir,

I have the honor to enclose a detailed statement of monies expended on account of the magnetic survey of N. America, amounting to £91. 10. 5½ Sterling and paid out of the sum allowed for contingent expenses of the observatory.

A sum of £50 Sterling per annum was granted "to meet the travelling and other incidental expenses of the survey" (see Estimate accompanying Board's letter Dec. 2nd, 1842 S/2355.) Commencing July, 1842, up to Dec. 1845, this amounted to £175, out of which £72.0.7 has been paid for travelling expenses *alone*, your predecessor, Mr. Harvey, declining to make payments on any other account.

A late letter from the Honorable Board of Ordnance, dated August 5th, 1846, S/2069, having stated explicitly, for what purpose this £50 a year was granted, in the following words: "The £50 a year allowed for the contingent

expenses of the magnetic survey, is designed to cover the repair and necessary replacement of instruments employed in the survey, and also other incidental charges incurred in the prosecution of the survey, as well as the item for travelling expenses."

I have to request that you will credit the contingent account of the observatory with the sum of £91.10.5½ deducted from the balance remaining to the credit of the survey account.

I have, etc.
C.W.Y.

W. A. Holwell, Esq.,
Department Ordance Storekeeper, Toronto.

During this period the connection with King's College was enlivened by an incident of minor consequence. On October 1st, 1846, Younghusband wrote to the Bursar of King's College—"I have to request you will call the attention of the Council of King's College to the danger and annoyance to which persons are constantly subjected from shooting matches taking place within, and in the vicinity of, the University Grounds.

"The danger of which I complain is not from guns of persons engaged in a match, but from those of men and boys collected in consequence, who surround the field and fire in the most reckless manner at birds endeavouring to escape.

"I may mention as an instance that yesterday afternoon 5 different discharges passed through the windows of the observatory on the ground floor."

As this incident was not mentioned again, we may assume that the complaint was heeded.

On November 17th, 1846, Younghusband wrote to Lieut. and Acting Adjutant N. Mackay ". . . . that I purpose quitting Toronto on Monday the 23rd instant, before which time Captain Lefroy will in all probability have arrived, having sailed from England on the 11th October. In case he has not reached Toronto, Sergeant James Johnston will take charge of the Detachment." And on the 21st Captain Lefroy notified Lieut. Col. Dalton ". . . . that I arrived in Toronto on return from leave of absence yesterday the 20th instant, and have resumed the direction of the magnetic observatory. I left England in the American Packet-Ship *Liverpool*, from Liverpool, on the 12th October, and landed in New York on the 14th November, having found my own passage."

Younghusband shortly afterwards returned to England to assist Colonel Sabine in the compilation of the records of observations taken in the world-wide magnetic survey.

(To be continued.)

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[57]LEFROY, *Autobiography*, p. 63.

[58]The home of Sir John Beverley Robinson, 1791-1863, Chief Justice of Upper Canada.

[59]*Op. cit.*, p. 63. [60]*Op cit.*, p. 106. [61]*Op. cit.*, p. 107.

[62]*Op. cit.*, p. 108.

[63]*Op. cit.*, p. 113.

[64]This JOURNAL, 1941, p. 221.

[65]In the following letters this signature will be abbreviated.

[66]A note by Lefroy states that "The above letter was cancelled, and another written—but which has not been entered. J. H. L."

[67]It will be noticed that this information was given to Lefroy as early as October 29, and that official confirmation only, without which no action could be taken, was delayed.

[68]This JOURNAL, 1941, p. 208 *et seq.*

[69]*Op. cit.*, p. 223.

[70]Lefroy was promoted to the rank of Captain about this time. The last letter signed "Lieutenant" is dated January 24, 1846, and the first signed "Captain" is dated February 25, 1846.

[71]LEFROY, *Autobiography*, p. 107.

[72]On July 9, 1846, there was a further complaint about Grace: "I regret to report the continued misconduct of Bombardier W. Grace of Captain Symon's company, 1st Battallion. He was absent from his Barracks on the night of the 8th July, and did not return until 9 a.m. this morning.

"As I feel that such irregularity renders him unworthy of trust in his present situation, I have the honor to request that an intelligent N.C.O. or Gunner may be sent to relieve him at the earliest opportunity.

"I have, etc. C. W. Younghusband, etc."

This letter was addressed to Lieut. Col. Dalton, Commanding Royal Artillery, Canada West. On July 20th, 1846, Younghusband informed Lieut. and Adjutant Mackay at Kingston "Bombardier W. Grace will leave this day in the steamer for Kingston." On July 23rd Younghusband informed Lieut. Col. Sabine "that owing to repeated acts of misconduct on the part of Bombardier William Grace . . . [he] could place no confidence whatever in him" and that "in exchange, Bombardier James Lennon of Captain Symond's Company, 1st Battallion, has been attached to the magnetical observatory detachment. Bombardier Lennon appears a steady and intelligent young man, giving good promise for the future."

On the same day he wrote also to state the charge preferred against Grace:

"For being absent from Tattoo Roll Call on the evening of the 8th July, 1846, and not returning until at or about 9 a.m. of the 9th July, 1846."

In another letter dated July 27th, 1846, he mentions an earlier charge that was preferred against Grace: "For being absent from Tattoo Roll Call on the evening of the 22nd June, 1846, and not returning until at or about 2 a.m. of the 23rd June, 1846." On this occasion Grace had been "admonished and released. C.W.Y."

[73]Letter dated August 24, 1846. Lefroy made striking comment on Corporal Henry in his memoirs. (See *Autobiography*, p. 80.) ". . . I must acknowledge that I did not make a companion of Corporal Henry. The distance which separates the officer and the soldier is great, and in character he was taciturn, without a particle of vivacity, making a grievance where he could, looking with contempt on the Canadians, with whom he never associated more than he could help, and on their language, of which he hardly learnt a word except 'shudder' for *chaudière*, kettle, and such-like. He was also unsociable and uncommunicative to the last degree, and I scarcely ever saw him unbend or take any part in the occasional practical jokes which the Canadians indulged in, or show a warm interest in anything; yet he was very faithful and useful as an assistant and soldier-servant, and had I been differently constituted myself I might no doubt have drawn more out of him.

"Corporal W. Henry eventually rose to be sergeant-major, then was commissioned as adjutant in the first transport corps organized for the Crimean war, and finally retired from the service in 1877, with the rank of colonel. He died in 1881."

CONVERSION OF MEAN AND SIDEREAL TIME

By C. A. CHANT

THE conversion of a reading on the mean time clock into the reading at the same instant on the sidereal clock at the same place is an ordinary operation in astronomy, and this brief article is intended to show how it can be done by using the OBSERVER'S HANDBOOK.

Sidereal Time and Mean Time. There are two kinds of time in common use by astronomers, (1) Sidereal, or stellar, time; (2) Mean solar time, which is that used by our ordinary clocks. Another sort may also be mentioned, namely, Apparent solar time, which is shown by the sun-dial.

In the accompanying diagram the circle represents the celestial equator. The meridian plane for any place passes through the celestial pole, the observer at O and his zenith. Let this plane cut the celestial equator at M and N.

The sun moves among the stars upon a great circle in the sky (the ecliptic) which cuts the celestial equator in two places which are known as equinoctial points. That point where the sun is at the spring equinox (Mar. 21) is denoted by ♈ in the figure. It is frequently called the First of Aries. It has a very slow motion along the ecliptic, known as the precession of the equinoxes; but for our present purpose ♈ may be considered as occupying a fixed position in the celestial equator, i.e., fixed with respect to the stars.

On account of the rotation of the earth the point ♈ appears to move around the celestial equator from E. to W. every day, and a clock may be regulated to keep time with it. When ♈ is at M the sidereal time is $0^h\ 0^m\ 0^s$; when it has moved 15° to the west the sidereal time is $1^h\ 0^m\ 0^s$; when it has moved (say) 63°, the sidereal time is $4^h\ 12^m$. Any arc (or angle) may be converted into equivalent time units from the relations:

$$360° = 24^h \text{ or } 15° = 1^h,\ 1° = 4 \text{ m.},\ 1' = 4 \text{ s.}$$

The time elapsing from the instant when ♈ is on the meridian until it is there again is a sidereal day. Sidereal days are equal in length.

The real sun moves around the ecliptic, but does not travel with perfect uniformity. The time taken to go from ♈ around to ♈ again is called a Tropical Year. It is the common year by which we regulate our lives. The instant each day when the centre of the real sun is in the meridian plane (at which time its projection on the celestial equator is at M), is Apparent Noon, and the interval from one Apparent Noon to the next one is an Apparent Solar Day. Now the apparent solar days are not all equal, and it is desirable that the days in common use should be. So in order to accomplish

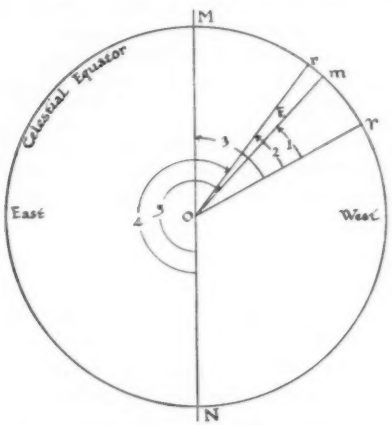

DIAGRAM ILLUSTRATING DIFFERENT KINDS OF TIME.

The circle is the celestial equator, with the observer at the centre O; MN is the meridian plane.

this end we imagine a point which moves among the stars, along the celestial equator, at the average rate of motion of the real sun in the ecliptic. This is the Mean Sun and we use it instead of the real sun. It is adjusted to be as much behind as it is before the real sun during their annual motions. When, in its daily motion, as it is seemingly carried round by the sky, the mean sun is at M, on the meridian ***above***, the time is mean noon; when it is at N, on the meridian ***below***, the time is mean midnight. The interval required for it to move from N around to N again is a mean solar

day; and when so defined—i.e., from midnight to midnight—it is the ordinary civil day of the calendar. Mean solar days are all equal, and there are 365.2422 (or $365\frac{1}{4}$ approx.) mean solar days in a tropical year.

Since by definition the mean sun is continually travelling eastward along the celestial equator, a mean solar day is longer than a sidereal day. If the mean sun and ♈ are at M together (as they are sometime about March 21), next day, through the diurnal rotation of the sky, ♈ will arrive at M before the m.s. does, or the sidereal clock will have gained on the mean time clock. This gain continues, and a year later when ♈ and the m.s. are together at M again, the sidereal clock will have gained 24 hours on the mean time clock. Now there are $365\frac{1}{4}$ m.s. days in the year; hence there are $366\frac{1}{4}$ sidereal days in the year. Thus we have the relations:

$365\frac{1}{4}$ m.s. days $= 366\frac{1}{4}$ sid. days;

from which

1 sid. day = 23h. 56m. 4s. of mean time,

1 m.s. day = 24h. 3m. 57s. of sid. time.

Thus the sidereal clock in 1 m.s. day gains 3m. 57s. From the above relations an interval given in m.s. time can be expressed in sidereal time, and likewise an interval stated in sidereal time can be expressed in mean time units. The practical astronomer often finds it necessary to make these calculations of time; and, to relieve the labour, tables are given in the astronomical almanacs, the best known of which are the *Nautical Almanac* (British), usually abbreviated *N.A.*, and the *American Ephemeris and Nautical Almanac*, or *Am. Eph.* for short.

Hour Angle. Referring again to the diagram, let m be the mean sun, r the projection on the celestial equator of the real sun. Then the arc ♈ m or "1" is the right ascension of the mean sun, ♈ r or "2" is the R.A. of the real sun, and ♈M or "3" is the R.A. of the observer's meridian. Also, M♈ is the hour angle of the First of Aries, or the sidereal time. From the figure this is seen to be equal to ♈M, and we can make the fundamental statement that the R.A. of the meridian is equal to the sidereal time. Suppose Betelgeuse (R.A. $5^h\ 50^m$) is observed to be on the meridian; the sidereal clock should read $5^h\ 50^m$. By agreement among astronomers the angle expressing the mean time is measured from N, the

meridian below. In the diagram this is given by the arc NMm or "4"; this is the civil mean time. For r the angle is NMr, or "5", which is the apparent solar time. The little angle E, which is the difference between "1" and "2", or between "4" and "5", is the equation of time. It is usually defined thus:

apparent time − mean time = equation of time,

and in the circumstances shown in the figure it is a minus quantity. The correction to the sundial is the equation of time as just defined, with its sign changed. (See OBSERVER'S HANDBOOK, p. 8.)

Conversion of Mean and Sidereal Time. In order to convert the mean time into the sidereal time at the same instant and the same place, we must be supplied with the readings of the mean time clock and the sidereal clock at a specified instant and place; also we must know the longitude of the place of the observer.

Longitude. Let us consider a station at Toronto which is in longitude $5^h\ 17^m\ 35^s$ west from Greenwich. If you could observe simultaneously—(say) by television—two clocks showing the *same kind* of time (either mean time or sidereal time), one at Toronto and the other at Greenwich, then the Toronto clock will be $5^h\ 17^m\ 35^s$ slow of the Greenwich clock.

Example, (1) using the OBSERVER'S HANDBOOK. Given the reading on the mean time clock, let us find the corresponding sidereal time.

Observer's station, in W. long. 118° 43′.5 or $7^h\ 54^m\ 54^s$.

Instant of time, $9^h\ 23^m$ p.m. Pacific Standard Time, August 15, 1942.

Observer's time	9^h	23^m	p.m. P.S.T.	
Add long. of 120th mer.	8	00		
Gr. Time on p.m. of Aug. 15	17	23		
which is G.C.T.	5	23	Aug. 16	

We first find the Sid. T. at Greenwich at this instant.

From the diagram

ΥM, the Sid. T., = "2" + "4" − 12^h = "2" + "5" − E − 12^h.

Now "2" is the R.A. of the real sun; and from Table p. 7

On Aug. 14 at G.C.T. 0^h "2" is	9^h	31^m	55^s	....A
" 17 " " " "	9	43	10	
Increase in 3 days		11	15	
" " $2^d\ 5^h\ 23^m$		8	20	....B
R.A. of real sun at instant	9	40	15	....A+B
Add G.C.T. at instant, or "5".	5	23		
	15	3	15	

Subt. value of E at instant...	−	4	21	
	14	58	54	
Subt. 12^h	−12	00	00	
Sid. T. at Greenwich	2	58	54	on Aug. 16
For station, subt. long.	− 7	54	54	
Sid. T. at station	19	4	00	on Aug. 15

(2) *Using a Nautical Almanac.* In this case the labour is almost negligible.

Given instant, Aug. 15, 1942, P.S.T.	21^h	23^m	Civil Time
Adding 8^h for 120th mer. this is G.C.T.	5	23	Aug. 16..A

From *Am. Eph.*, p. 10, we have

Aug. 15, Sid. T. at Greenwich, at 0^h G.C.T.	21^h	35^m	01^s.....B
Gain of Sid. T. in 5^h 23^m (p. 536)		0	53 C
Gr. Sid. T. at Greenwich at instant, A+B+C	26	58	54
Change for long.	7	54	54
Sid. T. at station	19	04	00

Other examples, including conversion from sidereal to mean solar time, are given in the Almanacs.

David Dunlap Observatory,
Richmond Hill, Ont.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

A New Distant Planet?

There was reported by K. Aa. Strand at a meeting of the American Philosophical Society in Philadelphia, evidence for the existence of an unseen object, possibly a massive planet, associated with a double star in Cygnus. This was also reprinted in the local press. No details of Dr. Strand's paper are as yet available. The use of the term "planet" leads to speculation as to its nature. In this case it may merely refer to an object which emits no visible light of its own, and may not be at all similar to the solid planets of our solar system. Further information from Dr. Strand's paper is necessary to settle these questions. C. A. C.

Jupiter and Satellites, I, II, III, IV, during 1943

The following table gives the sixteen periods during 1943 when Jupiter apparently will be attended by only one, and on September 27th by no satellite. The next periods of the cycle occur after an interval of about 21 months. Time given is that of longitude 75° West. Configurations are for an inverting telescope.

1943	*Configuration*	*Begins at*	*Ends at*	*Duration*
Jan. 27	***-0-1	$2^h\ 10.^m$	$2^h\ 45.^m1$	$0^h\ 35.^m1$
Feb. 3	d**-0-4	5 29.	6 45.1	1 16.1
" 13	d*d-0-4	20 07.	21 37.	1 30.
" 17	d**-0-4	9 01.	11 16.	2 15.
" 28	4-0-d*d	1 15.	1 58.	0 43.
Mar. 1	3-0-*dd†	18 43.	20 25.	1 42.
Aug. 24	*d*-0-3	21 49.6	22 52.	1 02.4
Sept. 2	*dd-0-4	18 11.6	19 02.	0 50.4
" 6	*d*-0-4	7 08.3	9 09.	2 00.7
" 9	d*d-0-4‡	20 22.	23 02.	2 40.
" 13	4-0-**d	9 45.	12 02.	2 17.
" 17	4-0-*dd	0 11.	1 01.	0 50.
" 18	3-0-***	18 35.1	19 31.	0 55.9
" 20	**d-0-4	12 30.	14 01.	1 31.
" 27	-0-d**d	15 14.	16 0.	0 46.
Nov. 17	2-0-d*d	0 35.	2 01.	1 26.

†Satellites I, II, IV disappear within $37.^m8$

‡ " I, II, III " " $34.^m$

Westfield, N.J. Charles E. Apgar.
February 20, 1942.

VERSES BY THE RECORDER OF THE R.A.S.C.

Mr. Herbert W. Barker at present is Recorder for the General Council of the R.A.S.C. He was General Treasurer 1919-1931. For over 25 years he was on the staffs of the Traders and Royal Banks in Toronto; and from 1926 to 1939 he was Deputy Treasurer of the United Church of Canada. Members of the Society will wish Mr. Barker many more useful years.

C. A. C.

ON PASSING THREE SCORE YEARS AND TEN

Alas, too soon the sands of time in flowing
Have counted out life's full allotted span;
And now, content, I quietly wait, not knowing
What's hidden in God's plan.

A little while—how short I cannot measure—
Is left to me before the close of day;
But, short or long, I am, by God's good pleasure,
Willing to go or stay.

These later years in passing have made clearer
Keenness of eye and ear for things unseen;
Faces and voices long since gone seem nearer
Than hitherto they've been.

Activities give place to meditation,
And hurried pace to mem'ries of the past;
And all earth's values lose consideration
When weighed with things that last.

The western sun is gradually declining,
Length'ning the shadows on my homeward way;
But soon I'll see the sun more brightly shining
In heaven's perfect day.

H. W. BARKER

MINUTES OF SUMMER MEETINGS—TORONTO, 1942

Four outdoor observation meetings were held on the front campus of the University of Toronto during the summer season; on June 22, July 20, August 21 and September 21. Many visitors, in addition to members of the Society, were present on each occasion to observe the moon and stellar objects. Unfortunately there were no planets in suitable position for observation during the summer months. Many members of the Royal Canadian Air Force, taking classes at the university, were among those who availed themselves of the opportunity for observing the skies and numerous questions were asked by these and other visitors, and answered by the members in charge of the instruments.

Four telescopes were set up on the first night; one only in July, and three each at the August and September meetings. The university's four-inch Zeiss refractor was in use on each occasion, and the Society's four-inch Cooke refractor was set up for three meetings. Mr. H. V. Wilkins brought his six-inch reflector on three nights and was assisted in its operation by Mr. K. Dalzell. Mr. S. Butler also brought his own small instrument for the June observation night. Mr. C. A. Crook and Mr. W. R. Sherrick also ably assisted, particularly on July 20 when other members of the committee in charge except the Recorder were out-of-town on vacation.

The meetings were in charge of a special committee consisting of Dr. D. W. Best, Miss Ruth J. Northcott, Mr. F. L. Troyer and Mr. T. H. Mason. Clouds interfered with observing on three evenings, particularly in July when an overcast sky threatened to cause cancellation of the program. The sky cleared for a hour and a half after sunset, however, and a large number of persons were present to view the moon and double stars before heavy clouds again spread over the sky. A violent thunderstorm broke just a few minutes after the telescope was prematurely put away. Some cloud and considerable haziness again interfered to an extent on August 21, but better weather was experienced in September. From 100 to 200 persons were present on each of the four nights and most of them joined the line several times to take a second and third look at the moon or to view other objects.

FREDERIC L. TROYER, *Recorder.*

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